Development and Optimization of the Combustion Process Using Oxymethylene Ethers on a CI Engine

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Clusters
Lichtenberg Cluster Darmstadt

Additional Software
AVL Fire

Institute
Institut für Verbrennungskraftmaschinen und Fahrzeugantriebe

University
Technische Universität Darmstadt

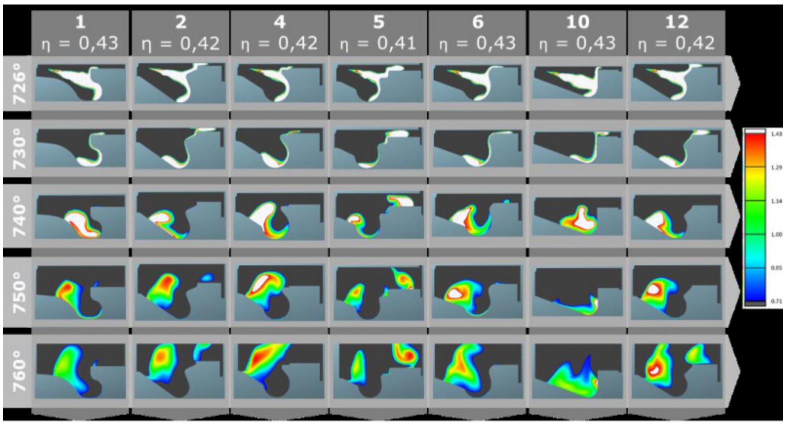

Figure 1: Analysis of the mixture formation and resulting efficiencies from different bowl geometries.

Introduction

The automotive industry is currently significantly driven by the reduction of CO2 and pollutant emissions. Lots of work in research and development of internal combustion engines is carried out on engine test beds, which is expensive and time consuming. Increasingly, however, work in the development process is being shifted to an earlier period ("frontloading") and carried out in a simulation environment. For example, combustion behaviour and emission formation can be calculated with three-dimensional computational fluid dynamics (3D CFD). However, complex simulation models require more computing resources, which is more time consuming with ordinary desktop computers. Therefore, computing time on the Lichtenberg Cluster is necessary for detailed analysis.
Synthetic fuels are becoming an increasingly important issue alongside fuel cell vehicles, electric or hybrid vehicles. Research and development of corresponding reaction kinetics for synthetic fuels are currently the subject of various research projects.
The institute of internal combustion engines and powertrain systems is operating a single cylinder research engine to investigate synthetic fuels. The computing resources at the Lichtenberg Cluster will be used to perform simulations both in a simplified model and in a complex, full engine model.

Methods

The used software (AVL Fire) consists of different program parts for different kinds of simulation tasks. ESE Diesel is a subprogram which is like a simplified simulation tool for quick

model setup of the combustion chamber and reduced computing time. Other parts of the engine, e.g. intake and exhaust manifold, valves, oil and cooling circuit etc. are not considered. Usually, the simulation time is limited to the high-pressure phase of the engine process. Accordingly, the gas exchange is not considered. Furthermore, in case of a symmetrical combustion chamber, only a section of it is considered and this is scaled to the entire combustion chamber. This leads to a shorter computing time compared to a full engine model and the simulation of the entire engine process. ESE diesel is used for a broad screening of many parameters.
Workflow Manager is a subprogram in which different types of geometries can be imported, prepared and simulated. For example, detailed simulation of a full engine model with intake and exhaust manifolds, valves and the combustion chamber are possible. Usually, the full engine cycle (intake, compression, combustion/work, exhaust) is simulated. Due to the higher model complexity, simulation is more time consuming and therefore more computing resources are necessary.

Results

Unfortunately, no results could be generated using the Lichtenberg Cluster. Due to the lack of licensing and of reaction kinetics, no activity was initially possible on the cluster.
Still, some preliminary work has been done with the software and its subprograms using desktop computers at the institute for internal combustion engines and powertrain systems. A simplified model of the single cylinder research engine was implemented in ESE diesel. So far, this model was validated with measurement data from the engine testbed. Various parameter studies like different bowl geometries were performed. The creation of the full engine model in Workflow Manager was started. Due to the high complexity, however, there is still some work to be done here. Testing and troubleshooting/debugging are very time consuming due to limited computing power. For this, the operation on the Lichtenberg Cluster would be very helpful.
Simulations were performed with conventional diesel fuel kinetics because reaction kinetics for the used synthetic fuel were not available at that point.

Discussion

The single cylinder research engine was modelled in ESE diesel (simplified model) and also in Workflow manager (detailed model). Implementation of the full engine model (Workflow manager) is still ongoing. The simplified model in ESE diesel has been optimized and validated with measurement data and gives good results.

Outlook

Next there will be parameter studies like variation of the engine compression ratio, further bowl geometries or optimization of a

particular geometry as well as variation of swirl and tumble.
Target is to optimize the mixture formation to reduce pollutant emissions.
Furthermore, the full engine model will be further developed and set into operation. With the full engine model, the knowledge gained from the simulation should be increased.
Due to the size of the model and the comparatively large number of cells, the computation time on normal office computers is very large, which is why Lichtenberg Cluster is urgently needed for work on the full engine model.

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